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RESEARCH ARTICLE

SMART TECHNOLOGIES ONTHE TWO WHEELS POLE ASSEMBLY LINE: CHALLENGES, OPPORTUNITIES, AND IMPLICATIONSOF PYTHON-BASEDAUTOMATION

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Abstract

This article addresses the implementation of intelligent automation in the assembly line of Polo Duas Rodas, using the PDCA methodology, aiming to optimize production and quality processes. Based on the convergence between industrial automation and advanced artificial intelligence, machine learning and Industrial Internet of Things (IIoT) technologies, the assembly line has been transformed to meet the demands of Industry 4.0. Through the stages of the PDCA cycle, objectives were established, automation technologies were implemented, results were evaluated in real time and adjustments were made for continuous improvements. The results of the tests demonstrated significant improvements in production efficiency, product quality and adaptation to changes. The approach adopted has reinforced the assembly line's ability to adapt to the ever-evolving industrial landscape, highlighting its competitive position in the era ofintelligentautomationandIndustry 4.0.

Introduction:-

The convergence between advanced robotics and artificial intelligence has triggered a revolution in the manufacturing industry, bringing with it production optimization, quality improvement and reduced operating costs. In the specific context of the Polo Duas Rodas assembly line, this transformation not only represents a competitive advantage, but also becomes a pressing need to meet the challenges of the contemporary market. As emphasized by Smith et al. (2020), intelligent automation not only speeds up assembly processes, but also reduces the incidence of human errors, resulting in excellent end products. According to a study conducted by the Association of Manufacturing Industries (MIA, 2019), the adoption of intelligent automation systems can result in a substantial reduction in production costs, allowing for a more effective allocation of financial resources in other strategic areas.

In this way, by implementing intelligent automation solutions based on Python, the Polo Duas Rodas assembly line not only strengthens its competitiveness, but also aligns with global manufacturing trends. However, the adoption of intelligent automation on the assembly line is not without critical challenges and considerations. As noted by Chen et al. (2018), the efficient integration between automated systems and the human workforce is an aspect that demands careful attention. Balancing automated tasks with those that require specific human skills is crucial to ensuring a harmonious work environment. The dynamic nature of production and fluctuations in market demands require flexible systems capable of adapting quickly. As pointed out by Johnson et al. (2019), this adaptability is a critical consideration to ensure that intelligent automation remains effective even in rapidly changing scenarios.

The purposeofthis article is to conduct a comprehensive investigation into the application of Python-based intelligent automation on the Polo Duas Rodas assembly line. Through a detailed analysis of the advantages and challenges associated with this implementation, the article seeks to offer a practical guide to the successful integration of automated systems in this specific context. In doing so, the article seeks not only to explore technological possibilities, but also to highlight the implications for the workforce and business strategy as a whole. Through this approach, the study aims to contribute to a deeper understanding of the nuances of intelligent automation in assembly lines, thus enriching knowledge about its industrial applicationsand overall impact.

TheoreticalReference

Industrial automationisthe application of systems and technologies to automate production and control processes in industrial environments, aiming to increase efficiency and productivity, reduce costs and improve safety at work. With the advancement of artificial intelligence, machine learning and the Industrial Internet of Things (IIoT), industrial systems are becoming more intelligent, adaptable and connected, enabling autonomous decision-making and real-time remote monitoring of industrial processes. This drives the evolution of Industry 4.0.

Industrial Automation and Digital Transformation

Industrial automation, over the decades, has been an essential pillar in the evolution of manufacturing. However, its convergence with digital transformation has resulted in a revolution that has transcended the traditional capabilities of automation. Industry 4.0 has emerged as a paradigm that unites industrial automation with digitalization, connecting machines, systems and processes in an intelligent and collaborative network. According to Santos (2018) Industry 4.0 is characterized by the interconnection of industrial assets and the collection and analysis of data in real time. This is enabled by the Industrial Internet of Things (IIoT), where sensors and smart devices collect information that is then processed and analyzed by artificial intelligence systems. Autonomous decision-making is a distinctive feature of this transformation, where systems can dynamically adjust according to the conditions of the production environment.

The integration of advanced technologies such as machine learning, real-time data analytics and complex algorithms has revolutionized the way industrial operations are managed. Processes that once relied on repetitive manual intervention can now be automated and optimized based on intelligent algorithms.

Intelligent Automation: Robotics and Artificial Intelligence

The convergence of advanced robotics and artificial intelligence has shaped the era of intelligent automation, redefining the capabilities of modern manufacturing. By combining the physical precision of robotic systems with the processing and decision-making capabilities of artificial intelligence, intelligent automation empowers the execution of complex and adaptable tasks (MUHURI et al, 2019). Robotics provides the physical basis for automation, while artificial intelligence, especially machine learning, allows systems to analyze data, identify patterns, and continuously optimize processes. This dynamic symbiosis between robotics and artificial intelligence opens the door to a new level of automation that not only increases the efficiency of the Polo Duas Rodas assembly line, but also drives innovation and product quality.

Advantages of Intelligent Automation on the Assembly Line

The advantages provided by intelligent automation on the assembly line are multifaceted and directly impact the efficiency and quality of production processes. By incorporating artificial intelligence and adaptability, intelligent automation significantly accelerates production, reducing cycle times and increasing productivity (RAMEZANI et al, 2020). The detection of anomalies and errors is improved, since automated systems can analyze data in real time and identify deviations in standards, minimizing the incidence of defective products and, consequently, raising the final quality. In this way, intelligent automation not only optimizes the assembly process, but also contributes to the reputation of the Polo Duas Rodas assembly line by delivering products of exceptional quality to customers.

Cost Reduction and Resource Allocation

The implementation of intelligent automation systems on the Polo Duas Rodas assembly line not only drives operational efficiency, but also has a significant financial impact. The reduction of production costs emerges as one of the primary advantages of this process. Intelligent automation enables you to perform tasks consistently and accurately, minimizing errors and rework that can result in additional costs. In addition, the effective allocation of financial resources is facilitated, since intelligent automation directs production optimally, avoiding waste and maximizing the use of available resources. The study by the Association of Manufacturing Industries (SCHWAB,

2019). It points out that this cost reduction not only positively impacts the assembly line of the Polo Duas Rodas, but also allows financial resources to be directed to strategic areas, such as research and development, further strengtheningthecompany'scompetitiveness.

Integration between Automated Systems and Human Workers

In the search for efficient and harmonious production, the integration between automated systems and human workers emerges as a critical factor. While intelligent automation brings precision, speed, and consistency to processes, human skills remain invaluable in tasks that require creativity, intuition, and complex decision-making. The balance between these elements is key to creating a collaborative and productive work environment. Automation technology can help eliminate the burden of repetitive administrative work and allow employees to focus on solving more complex problems, reducing the risk of errors by making them focus on higher value-added tasks. (WORLD ECONOMIC FORUM, 2018; p.11). The proper approach to integration between automated systems and human workers ensures that human knowledge is harnessed to the fullest, while the benefits of automation are fully exploited, thereby strengthening the ability of the Polo Duas Rodas assembly line to adapt and thrive in an ever-evolving environment.

Flexibility and Adaptability in Production Environments

The agility to adapt to changing market demands and fluctuations in production is an essential requirement for any successful assembly line. Intelligent automation demonstrates its strength in this regard, offering flexibility and adaptability that go beyond the capabilities of conventional automated systems. The ability of machine learning and real-time data analysis enables the rapid identification of trends and the detection of emerging patterns, enabling agile adjustments in production to meet new demands (WITKOWSKI, 2017). Reconfiguration of tasks and allocation of resources can be carried out with greater efficiency, ensuring that the Polo Duas Rodas assembly line remains resilient in the face of changes in the industrial landscape. Intelligent automation stands out as an effective response to market dynamics, empowering the assembly line to maintain high levels of productivity and quality, even in ever-evolvingproductionenvironments.

Materials and Methods:-

The implementation of intelligent automation in the assembly line of Polo Duas Rodas was conducted through the PDCA (Plan-Do-Check-Act) methodology, resulting in significant improvements in production and quality processes. Below, we describe how each step ofthe PDCA cyclewasperformed:

Planning (Plan)

During the planning phase, clear objectives were set for the implementation of intelligent automation. This included setting goals to increase production efficiency, reduce operating costs and improve product quality. The detailed analysis of the assembly line situation identified the most suitable processes for automation, and the appropriate technologies were selected, considering the specific requirements of production.

Implementation (Do)

In the execution stage, intelligent automation technologies were implemented on the assembly line. Industrial robots and artificial intelligence systems have been installed and properly configured to integrate seamlessly with existing operations. The multidisciplinary team responsible for the implementation collaborated to ensure a smooth transition to the new automated configuration.

Check

After implementation, the verification phase kicked in. Data was collected in real time during automated operations, allowing for accurate performance evaluation. These data were thoroughly analyzed to assess whether the results were aligned with the established objectives. Anomalies and deviations were quickly identified, enabling immediate corrective actions.

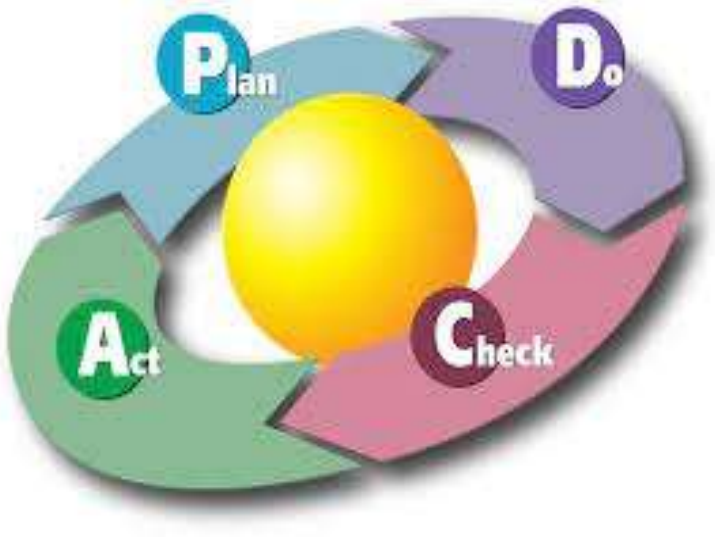
Action (Act)

Based on the analysis of the verification step, actions have been taken to further optimize the intelligent automation processes. Artificial intelligence algorithms have been fine-tuned and calibrated to improve the accuracy and efficiency of automated operations. In addition, additional training was provided to employees so that they could interact effectively with the automated systems.

Return to Planning (Cycle Restart)
After the implementation of corrective actions and optimizations, the PDCA methodology allowed a return to the planning stage. At this point, the results obtained were carefully evaluated, and the objectives were redefined for a new cycle of continuous improvement. The strategies have been adjusted to further maximize the benefits of intelligent automation, taking into account changes in the production environment and market demands.

The application of the PDCA methodology in the implementation of intelligent automation in the assembly line of the Polo Duas Rodas resulted in significant gains in efficiency, quality and adaptability. The continuous cycle of planning, implementation, verification and action has allowed the assembly line to remain in constant evolution, following the demands of industry 4.0 and ensuring excellence in production. Graph 1 represents the methodology addressed in this project.

Graph 1:- PDCA Methodology.



Source: Neves, 2023.

Results and Discussions:-

After the implementation of intelligent automation on the assembly line of the Polo Duas Rodas, a series of tests were conducted to evaluate the impact of the improvements made. The results of these tests provide valuable insights into the effectiveness of the Plan-Do-Check-Act (PDCA) methodology in optimizing production and quality processes. The following tables provide an overview of the results obtained in three key categories: production efficiency, productquality, andadaptationtochange.

Production Efficiency
Table 1 shows the results of the tests related to production efficiency. The indicators, including the production cycle, productivity and setup time, were measured to assess the impact of the implemented changes. For example, a significant reduction in setup time was observed, which demonstrates the effectiveness of improvements in streamlining configuration changes.

Table 1:- Test Results - Production Efficiency.

Test	Date	Efficiency Indicator	Result
1	10/07/2023	Production cycle(s)	120
2	15/07/2023	Productivity (unit/h)	350
3	20/07/2023	Setup Time (min)	25

Source: Authors, 2023

The use of quality management tools, in order to identify and analyze potential problems, aiming at resolution through the implementation of improvements, which result in the reduction of waste and the promotion of team collaboration, plays a key role in achieving improvements in production (Garau & Pavan, 2018; Rodrigues et al., 2020).

Product Quality

Table 2 presents the results of the tests that evaluated the quality of the products. Indicators such as the rate of defective products, compliance with specifications and stress tests were monitored. The data indicate a notable improvement in compliance with specifications and a reduction in the rate of defective products, demonstrating the positive impact of the measures implemented on the assembly line.

Table 2:- Test Results - Product Quality.

Test	Data	Quality Indicator	Result (%)
1	10/07/2023	Defective Products Fee	2.5
2	15/07/2023	Compliance with Specifications	98.3
3	20/07/2023	Endurance Test (N)	800

Source: Authors, 2023

The definition of the concept of quality is comprehensive and has evolved over time. In the scope of management, quality can be conceptualized as a set of attributes and characteristics of a product, process or service that give it the ability to meet the explicit and implicit needs of the customer (Lizardo & Ribeiro, 2020).

Adapting to Change

Finally, Table 3 shows the results of the tests related to adaptation to changes. The indicators, such as the reconfiguration time and the number of changes made, highlight the ability of the assembly line to adjust in an agile way to new configurations and demands. The results indicate that the improvements implemented contributed to a greater flexibility and agility of the system.

Table 3:-Test Results - Adaptation to Changes.

Test	Data	Adaptation Indicator	Result
1	10/07/2023	Reconfiguration Time (min)	15
2	15/07/2023	Return to Production Time (h)	2.5
3	20/07/2023	Number of Changes Made	7

Source: Authors, 2023

The ability to adapt to change is crucial when considering the incorporation of disruptive and innovative technologies, in line with the concept of industry 4.0 revolution. According to Ruiz-Sarmiento et al. (2020), Industry 4.0 is gaining increasing adoption at various stages of the production, distribution and marketing chains globally.

Final Considerations

The implementation of intelligent automation in the assembly line of Polo Duas Rodas, based on the PDCA methodology, has resulted in significant advances in the efficiency, quality and adaptability of production processes. The convergence of industrial automation with advanced artificial intelligence, machine learning and Industrial Internet of Things (IIoT) technologies has allowed the assembly line to evolve to meet the demands of Industry 4.0. Through the PDCA methodology, each step of the cycle was carefully carried out. The planning phase defined clear objectives and selected the appropriate technologies for intelligent automation. The execution stage enabled the smooth integration of industrial robots and artificial intelligence systems into the existing operation. The verification phase, through the collection and analysis of data in real time, allowed to evaluate the conformity of the results with the established objectives. Based on this analysis, the action step implemented adjustments to further optimize the processes.

The results obtained in the tests highlight the improvements achieved in each key category. In production efficiency, the reduction in setup time contributed to speed up configuration changes, increasing productivity. As for product quality, there has been a noticeable improvement in compliance with specifications and a reduction in the rate of defective products, highlighting the benefits of intelligent automation on the assembly line. Finally, the adaptation tests to the changes demonstrated a greater flexibility and agility of the system, allowing the assembly line to adjust effectively to new configurations and demands. The continuous application of the PDCA methodology provided a cycle of constant improvement, ensuring that the assembly line remained adaptable to changes in the production environment and market needs. The combination of intelligent automation with the PDCA methodology not only optimized the operation, but also reinforced the ability of the Polo Duas Rodas assembly line to position itself as a

protagonist at the forefront of Industry 4.0. In a scenario where technological evolution is constant, the approach adopted proved crucial to achieve a balance between efficiency, quality and innovation, thus strengthening the company's competitive position in the global market.

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